Tool for localized heating of material with directed thermal radiation

Tool for localized heating of material with directed thermal radiation, characterized

- in that at least two radiation sources of different kind are used for generating thermal radiation,
- in that at least one radiation source predominantly emits monochromatic radiation,
- in that at least another radiation source emits polychromatic radiation.

Description

Title

Tool for localized heating of material with directed thermal radiation.

Prior Art

Various tasks in the field of bonding or separating of materials are resolvable by thermal radiation. For example drying, annealing, melting, adhering, soft soldering, hard soldering or welding of metals and plastics are among these tasks. Radiation sources are classified by the kind or their radiation. Radiation sources emitting monochromatic light or polychromatic light can be distinguished, the wavelengths of said lights each being visible or invisible for the human eye.

In industrial use, tools with radiation sources emitting laser light or infrared light are used for contactless bonding or separation of materials using thermal radiation. The characterizing feature of all these tools is that only radiation sources of one kind can be used at a time for heating the point of operation. Thus, for example, tools for laser soldering and infrared or light soldering are available on the market /1/.

Due to the good radiation quality, laser systems have established themselves for a wide range of applications. Co_2, Nd:YAG and increasingly also semiconductor diode lasers serve as radiation sources /2/. The advantages of directed heating using laser beams are

- the exact focusing due to the coherent light of same wavelength,

- the possibility of precise direction and intensity control,
- the longevity of the laser source, particularly when using diode lasers, and
- the possible application of energy into the point of operation, which can be large if required.

Disadvantages of industrial laser systems are

- difficulties in process control,
- the efforts on control and safety purposes, and
- the considerable performance-related investment and operation costs.

Black emitters and high-temperature emitters are used when applying infrared light. Black emitters having a surface consisting of blackened metal plates or ceramic bodies are surface transmitters. They emit light with wavelengths in the range of 4-10 µm.

With high-temperature emitters all beams coming from a light source are focuses in a focal point using a semi-elliptical reflector. Standard light bulbs or standard discharge lamps are used as light sources. A modern light solder system by which the light of a halogen lamp is bundled via convergence mirror and optics, has been developed by ATN for single-spot soldering (DE 197 16 757 A1: publication document dated October 15, 1998) /3/. The advantages of directed heating with light referring to the tools are:

- low efforts on control and safety purposes, and
- relatively low investment and operation costs.

Last but not least the polychromatic light causes the following disadvantages:

- an exact focusing with focal point diameters of less than 2.0 mm can only be realized by a considerable technical effort,
- thus, the possibility of precise light beam positioning is impeded,
- the durability of the radiation source is short (ca. 50 – 100 h) /3/, and
- the maximum possible application of energy into the point of operation is relatively low.

Literature

/1/ Niemeier, J.: Entwicklung und Verifizierung eines Prozeßmodells für das Einzelpunktlöten in der Elektronikfertigung. Berlin, 1998.

/2/ Purbst, D.: Realisierbarkeitsstudie mikroelektronischer Laser-Lötkontakte durch transparente Substrate. Logos-Verlag, 1999.

/3/ Corporate publication ATN Automatisierungstechnik Niemeier GmbH, 1999.

Description of the invention

The invention is based on the problem that in tools for localized heating of material with directed thermal radiation only radiation sources of one kind are used for heating point of operations. Thus, the mentioned disadvantages of the exclusive heating with laser light or infrared light remain, which limit or even exclude possible ranges of application.

This problem is solved by combining one or more monochromatic light sources with one or more polychromatic light sources to a tool. Thus, the disadvantages of tools heating points of operation using only one kind of radiation are almost completely compensated.

The invention is based on the idea to reach desired maximum temperatures with localized heating processes in several stages using radiation sources of different kind. The whole process is run in at least two phases. During the preliminary phase the point of operation is preheated with polychromatic radiation wherein the maximum preheating temperature is below the desired maximum temperature. Thus, disadvantages of this kind of radiation source do not have any effect. The localized maximum temperature in the point of operation is generated with monochromatic laser light. Since the temperature difference to be generated between the preheating temperature and the maximum temperature is low the advantages of laser light in directed heating can be used.

The active principle is explained with the help of a thermal bonding process, as for example welding or soldering. For clarity reasons the mode of operation of a tool using monochromatic laser light and polychromatic light of a halogen lamp is described. Thereby, the maximum temperature

generated is below the deterioration limit of components of the point of operation. Subsequently, the melting process is realized by laser beams, the radiation intensity of which superimposes the radiation of the halogen lamp. The laser beam, in an exactly focused way, heats the point of operation until the desired maximum temperature is reached. By the preheating with halogen light the laser performance may be sized lower than in exclusive heating by a laser source. Thus its performance-related costs increase and the tool becomes more cost-effective with equal precision. The advantages of tools heating materials in a localized way with combined directed thermal radiation are:

- very precise local heating of points of operation,
- possibility of precise direction and intensity control of the thermal radiation,
- thus no undesired damaging of material in the vicinity of points of operation,
- the possible application of energy into the point of operation can be large,
- due to reduced performance and switching sequences the durability of polychromatic radiation sources is increased,
- due to reduced performance more cost-effective diode lasers can be used,
- thus no costly controls are necessary, and
- efforts on safety purposes decreases.

An advantageous design of the invention is indicated in claim 2. The further design according to claim 2 allows the use of cost-effective polychromatic radiation sources for preheating. In combination with the

laser light sources according to claim 2 the utmost precise directed heating of points of operation becomes possible.

Another advantageous design of the invention is indicated in claim 3. The design according to claim 3 enables the realization of tools which may be designed differently. Thus they may be adapted to a variety of different tasks in the field of localized heating of material with directed thermal radiation.

Another advantageous design of the invention is indicated in claim 4. The design according to claim 4 enables the suitable manipulation of the light path. Thereby it is possible to reach favorable temperature spreadings in the points of operation and thus high process qualities.

Exemplary embodiments

Figure 1 shows an exemplary embodiment of the invention. In this example, two radiation sources of different kind are located in different housings. In a housing (1) a halogen lamp (2) is located emitting polychromatic light. A convergence mirror (3) focuses said light (4= onto the point of operation (7) of the material (8). A semi-conductor diode laser (5) irradiates the point of operation in the operating area with predominantly monochromatic radiation (6). The beams of both sources hit the point of operation from different directions. By means of a holder (9) the housing are united to a tool for localized heating of material with directed thermal radiation.

Another exemplary embodiment is shown in **Figure 2**. Here, a halogen lamp (2) and a semi-conductor diode laser (5) are integrated in a common

housing (1). The polychromatic light (4) of the halogen lamp is focused onto the point of operation (7) of the material (8) by a convergence mirror (3). The diode laser is arranged such that the direction of its emitted radiation (6) coincides with the direction of the light beams (4) so that both kinds of radiation hit the point of operation from almost one direction.

Sample application

Year by year the component integration and thus the component concentration on electronic interconnect devices increases. At the same time the physical dimensions of he single components and the distances between the components decreases. The tend to smaller and smaller parts is a special challenge to the soldering technology. Thus, for example, accessing the soldering points, which themselves become smaller and smaller, becomes more difficult. Likewise, the mechanical contact with a component is to be avoided more and more often. Here, traditional soldering methods like hand soldering, but also contactlessly working soldering methods like light soldering reach their limits. With a soldering tool preheating the soldering points contactlessly with infrared radiation and subsequently soldering them with laser radiation all advantages of autonomic laser soldering devices are used. The very precise energy spreading and the punctiform application of energy into the soldering point excludes a plurality of possible errors. At the same time the preheating reduces the laser energy. The combined thermal radiation secures a favorable temperature spreading in the soldering point and thus soldering joints of high quality level. The soldering tool may advantageously be used in re-soldering and repair soldering as well as in micro-contacting and high-precision soldering. The sample application is shown in **Figure 3**. The components on the blank (1) are preheated with the light of a halogen lamp

(2) and subsequently soldered with monochromatic light generated by a diode laser (5). The required solder is applied by means of a soldering wire feed (4).

Claims

1. Tool for localized heating of material with directed thermal radiation, characterized
   - in that two radiation sources of different kind are used for generating thermal radiation,
   - in that at least one radiation source predominantly emits monochromatic radiation,
   - in that at least another radiation source emits polychromatic radiation.

2. Tool for localized heating of material with directed thermal radiation according to claim 1,
   characterized
   - in that predominantly monochromatic radiation is emitted from one or more Co_2, Nd:YAG or semiconductor diode lasers,
   - in that the polychromatic radiation is emitted from one or more light bulbs or standard discharge lamps.

3. Tool for localized heating of material with directed thermal radiation according to claim 1 and 2,
   characterized
   - in that all radiation sources are united in one functional unit thus forming a tool,
   - in that the radiation sources are located in housing, the number of which may differ from the number of present radiation sources.

4. Tool for localized heating of material with directed thermal radiation according to claim 1-3,

characterized

- in that the monochromatic beams and the polychromatic beams may hit the point of operation at the same angle but also at different angles,
- in that one or more housing designs or devices may co-determine the direction of the light path.

Captions

Figure 1: Exemplary embodiment 1

Figure 2: Exemplary embodiment 2

Figure 3: Sample application single-spot soldering

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In my capacity as a foreign language correspondence clerk for the English language, I, Iris Rehmann of Patentanwälte Rau, Schneck & Hübner, Königstrasse 2, D-90402 Nürnberg, Federal Republic of Germany, hereby declare that I am conversant with the English and German languages and that I am competent in translating respective documents thereof. I declare further that, to the best of my knowledge and belief, the annexed translation is a true, faithful and complete reproduction of German utility model DE 200 01 033 U1 filed with the German Patent and Trademark Office in the Name of Dipl.-Ing. Andreas Sonntag, 12169 Berlin/Germany on January 21, 2000, a copy of which has been submitted to me in the German language.

Nürnberg
February 28, 2011